TECHNICAL BULLETIN

Pre-commission cleaning

Five standard cleaning methods

Installations (boilers, heat exchangers, cooling water systems etc.) are often cleaned prior to being put into use. This procedure is called pre-commission cleaning. Various procedures carried out on the installation will have resulted in it being contaminated with grease/oil, welding scale etc. The temporary protective layer of the steel will moreover have been corroded resulting in (fly) rust. There are various methods for removing these types of contamination chemically.

The method chosen will depend on the technical aspects (which materials have been used for the construction of the system and what is the extent of the contamination) and the requirements of the customer. The proper assessment of which cleaning method to apply and the subsequent implementation of it, requires expertise. The following restricts its attention to the cleaning of installations constructed from carbon steel (C-steel) and the various cleaning methods that Vecom is able to perform (on site). Five pre-commission cleaning methods are discussed in turn.

Cleaning on the basis of hydrochloric acid

Cleaning with inhibited hydrochloric acid is a method that is frequently employed. Hydrochloric acid will ensure that the material is pickled fully, removing rust welding and mill scale effectively. When in addition to fly rust older rust (Fe_2O_3) is also present, hydrofluoric acid or another additive is introduced to prevent corrosion by ferric ion (Fe^{3+}). A standard treatment with hydrochloric acid comprises: degreasing, rinsing, pickling, rinsing, passivation. Passivation is conducted with ammonium citrate and an oxidizer forming a (temporary) stable uniform gamma-ferric oxide film. During cleaning large quantities of waste water are released as a result of the intermediate rinse phases. This water can be processed applying the DND principle (Detoxification, Neutralization, Dewatering).

IN GENERAL PRE-COMMISSION TREATMENT COMPRISES:

Degreasing

A degreasing step during pre-commission cleaning procedure need not involve (in all cases) strong agents. Not only light oil and grease contamination from processing will be removed, but also atmospheric contamination.

Pickling

A pickling phase will remove iron oxide (welding scale, when present, also).

Passivation

The steel surface will be active after pickling, rusting (fly rust) immediately. To counter this, the steel is temporarily protected. This can be realized by passivation, a chemical treatment during which a stable gamma- ferric oxide is formed. A standard passivation is conducted in ammonium citrate with an oxidizer.

Advantages: also dissolves mill scale; very suitable for heavily rusted material; standard procedure (well-known); in some cases the only suitable method.
Disadvantages: large quantities of waste water; various corrosive chemicals required; more time consuming; less operator and environmentally friendly; when improperly applied risk of damaging base material. Not able to be used on all steel materials (for instance on P91 material, like steam lines and superheaters, HCl is not suitable).

Cleaning on the basis of hydrofluoric acid

Cleaning with inhibited hydrofluoric acid is most common practise for new build steam boilers. This method is also fully described by the VGB guide lines “internal cleaning of water-tube steam generating plants and associated pipeworks” (VGBR513e). Hydrofluoric acid cleaning will ensure the material is pickled fully, removing rust, welding and mill scale and silicate compounds. This method can also be safely applied to steel alloys containing chromium (and steam piping like P91/92). The use of hydrofluoric acid has a major advantage in the later part

of the process: the effluent treatment. As the pickling solution is not drained (because of the formation of fly rust), but displaced with water, a passivation with ammonia/peroxide only is sufficient. In comparison with any other method the effluent treatment of this cleaning is relatively easy. Addition of lime precipitate the fluorides and iron as a sludge (DND method), which makes it possible to execute the waste water treatment on site. Most important value for discharging effluents after treatment is the chemical oxygen demand (or COD). This COD is directly correlated to the amount of organic contents of the water. Besides the inhibitor no organic compounds (like for instance citric acid) are used in this method, so relative low COD value of the effluent is met with this method.
Advantages: also dissolves mill scale and silicate (compounds); only suitable for power plants; standard procedure (VGB guide line); in some cases the only suitable method, easy to handle waste water treatment on site.
Disadvantages: large quantities of waste water; various corrosive and toxic chemicals required; very operator and environmentally unfriendly; when improperly applied risk of damaging base material.

Cleaning on the basis of citric acid
Cleaning with inhibited citric acid is conducted at a neutral pH. High temperatures are required however to remove the iron oxides. At elevated temperatures citric acid becomes more corrosive despite the neutral pH and inhibitors are required that may interfere with the second phase of the cleaning, passivation. Citric acid forms a strong complex with iron. Therefore the solution can be made alkaline without the iron precipitating as hydroxide. This means that with citric acid pickling and passivation can be conducted with one solution. When passivating, hydrogen peroxide or sodium nitrite is generally dosed. After cleaning, waste water is released that can be processed in a straightforward fashion by biological waste water purification or by the DND method.
Advantages: passivation with the cleaning solution; less waste water; method is suitable for removing copper.
Disadvantages: high operating temperatures; unable to remove mill scale in some cases; addition of chemicals during the passivation phase; less easy to treat effluent on site.

Cleaning on the basis of EDTA, Demclean 94®
The Demclean 94® cleaning method is based on EDTA in pH neutral media (see also TB 2004-06 of March 2004). This method not only removes iron oxides, but also light oil, grease and atmospheric contamination. The rust (iron oxides) is dissolved with the formation of a strong iron-EDTA complex. This allows the pH to be increased after cleaning without the iron precipitating as ferric hydroxide. After this neutralization, the steel is passivated by dosing sodium nitrite. This means that only one solution is required for pickling and passivation with less waste water being released. The waste water released by this cleaning procedure may be treated by biological water purification modified for EDTA processing.
Advantages: pH neutral cleaning agent; passivation with the cleaning solution; less waste water; not corrosive for other metals; time saving.
Disadvantages: addition of chemicals during the passivation phase; unable to remove mill scale; limited capacity for dissolving iron. Waste water can only be treated biologically.


Pre-commission cleaning on the basis of EDTA

Cleaning on the basis of VPX One Step®
The VPX One Step® process developed by Vecom consists of a cleaning procedure with a pH neutral solution, which dissolves the iron oxide allowing the underlying steel substrate to be phosphated. This process therefore pickles and passivates in one step. The fact that no other cleaning solution or addition of chemicals is required in order to passivate, is a major advantage because fewer environmentally harmful substances are used. VPX One Step® contains no toxic/corrosive constituents making this chemical cleaning procedure very environmentally and operator friendly. The waste phase is also free of problems. The waste water can be simply treated by the DND method. After cleaning a rinse phase is applied in which the waste released has a volume of twice the capacity. VPX One Step® will, thanks to its neutral pH, cause no problems when the installation incorporates also other metals such as copper, aluminium, zinc or stainless steel. VPX One Step® barely reacts with these metals, nor does it give rise to plating. VPX One Step® cannot be used to remove mill scale. A pre-treatment with hydrochloric acid should be used for that purpose.
Advantages: neutral; pickling and passivation in one step; operator and environmentally friendly; no reaction with other metals; fits in well with the boiler water treatment programme due to the presence of a phosphate film.
Disadvantages: process is not accepted worldwide; does not remove mill scale; removes very severe rust with difficulty; not cheap.

Conclusion
Each method has its advantages and disadvantages, the choice of method will be dependant very much on each process, type of installation, locality, budget, local regulations and even country. Every method should always be taken into consideration and discussed.

On the next page you will find a table with the various pre-commission cleaning methods.

Interested and want to know more?
For further information and/or questions about this subject or in case you have other questions, please contact one of our specialists via 0161 797 6666, projects@vecom.co.uk or go to our website.

	Demclean 94®	Hydrochloric acid	Hydrofluoric acid	Citric acid	VPX One Step®
Water consumption during cleaning	1 x system capacity	Pickling 1 X Rinsing 2 X Passivating 1 X Total 4 X capacity	Pickling 1 X Rinsing 2-3 X Passivating 1 X	1 X system	Pickling/passivating 1 X Rinsing 1 X Total 2 X capacity
pH cleaning solution	Neutral (5,0-5,5)	Acidic (< 1)	Acidic (1)	Acidic (3,0-3,5)	Neutral (6,0-6,5)
Operating temp. °C	50-60	40-50	50-70	70-80	40-50
Cleaning time (hrs)	24	48	48	24	15
Effluent treatment	Biological	DND, on site possible	DND, on site possible	DND/Biological	DND
Corrosive constituents during pickling phase	None	Yes, hydrocholoric acid	Yes, and toxic	Yes, citric acid	No
Pickling	Iron oxides (rust) and very light grease / atmospheric contamination	Iron oxides (rust) and mill scale and annealing skin	Iron oxides (rust) and mill scale and annealing skin and silicates	Iron oxides (rust)	Iron oxides (rust)
Passivation / passivation solution	After NH_3 neutralization with nitrite 1 step	After rinsing with ammonium citrate / peroxide 2 steps	After displacement of the acid with ammonia and peroxide	After NH_3 neutralization with H_2O_2 1 step	No extra dosing required. Passivation by phosphate formation
Maximum iron concentration	4 g/l	10 g/l	10 g/l	10 g/l	7 g/l
Possible on steel alloys with chromium or P91/92 material?	Yes	No	Yes	Yes	Yes, for Cr alloyed steel (not tested on P91/92)
Cleaning possible when pipes present of: Copper Stainless steel	 No Yes	 Yes No	 No Yes	 No Yes	 Yes Yes
Accepted worldwide	Yes	Yes	Yes (VGB guideline)	Yes	No

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